EXHAUST EMISSION CONTROL DEVICE

FIELD OF THE INVENTION

The present invention relates to an exhaust emission control device for an internal combustion engine.

BACKGROUND OF THE INVENTION

Tokkai Hei 9-228828 published by the Japanese Patent Office in 1997 discloses the reduction of hydrocarbons (hereafter *HC*) emissions immediately after engine start-up by the provision in the exhaust pipe of an *HC* absorbent catalytic converter, which is comprised of an *HC* absorbent material and a three-way catalyst. The *HC* absorbent material absorbs *HC* when the catalyst temperature is lower than a fixed temperature and emits *HC* at temperatures higher than the fixed temperature.

In such a way, *HC* emitted from the engine is temporarily absorbed by the *HC* absorbent material in the *HC* absorbent catalytic converter. When the temperature of exhaust gases in the *HC* absorbent catalytic converter reaches a fixed temperature, the air-fuel ratio is varied to a lean air-fuel ratio, that is to say, the air-fuel ratio is varied upwardly. This results in a super-oxygenated mixture in the exhaust gases and *HC* which is emitted from the *HC* absorbent material is oxidized by the three-way catalyst.

SUMMARY OF THE INVENTION

In this way, it is necessary to control an air-fuel ratio towards a lean air-fuel ratio from a stoichiometric air-fuel ratio and supply sufficient oxygen to react with emitted *HC* in the exhaust gas in order to improve the reduction of *HC* emissions. However the more an air-fuel ratio is varied towards a lean air-fuel ratio, the greater the amount of emitted nitrogen oxides (NO_x) becomes.

It is therefore an object of the present invention to remove *HC* while suppressing amounts of emitted NO_x when *HC* is emitted from an *HC* absorbent catalytic converter.

In order to achieve the above object, this invention provides an exhaust emission control device for an engine which is provided with an exhaust pipe. The emission control device comprises a first catalytic converter which contains the element *Rh*odium (*Rh*), and a second catalytic converter which contains *Rh* and a hydrocarbon (*HC*) absorbent material which absorbs *HC*. The first catalytic converter and the second catalytic converter are provided in series in the exhaust pipe and the *Rh* content by percentage in the second catalytic converter is higher than the *Rh* content by percentage in the first catalytic converter.

The details as well as other features and advantages of this invention are set forth in the remainder of the specification and are shown in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of an exhaust emission control device according to the present invention.

Figure 2 is similar to Figure 1, but showing a second embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figure 1 of the drawings, an exhaust emission control device for an engine 1 is provided with an exhaust manifold 2, an exhaust pipe 3, a three-way catalytic converter 4 and an *HC* absorbent catalytic converter 5.

The three-way catalytic converter 4 is provided in proximity to the exhaust manifold 2. The *HC* absorbent catalytic converter 5 has an *HC* absorbent material and a three-way catalyst and is provided downstream of the three-way catalytic converter 4.

The precious metal catalysts of the three-way catalytic converter 4 and the *HC* absorbent catalytic converter 5 comprise combinations of platinum (*Pt*) and rhodium (*Rh*), or palladium (*Pd*) and *Rh* or a combination of platinum (*Pt*), *Pd* and *Rh*.

The total amount of precious metal catalyst in the three-way catalytic converter 4 is greater than the total amount in the *HC* absorbent catalytic converter 5. However, the total amount of precious metal catalyst in the three-way catalytic converter 4 may be equal to the total amount in the *HC* absorbent catalytic converter 5. Otherwise, the total amount of the precious metal catalysts of the *HC* absorbent catalytic converter 5 may be greater than that of the three-way catalytic converter 4. However, in all cases above, the *Rh* content by percentage in the *HC* absorbent catalytic converter 5 is greater than the *Rh* content by percentage in the three-way catalytic converter 4.

The *HC* absorbent catalytic converter 5 comprises a coating of *HC* absorbent

material on the upstream half of a honeycomb shaped catalyst carrier and a coating of three-way catalyst on the downstream half of the carrier. Alternatively, the *HC* absorbent catalytic converter 5 has a coating of *HC* absorbent material on the surface of the honeycomb shaped catalyst carrier and a coating of a three-way catalyst on the coating of *HC* absorbent material. Alternatively, a coating comprising a mixture of an *HC* absorbent material and a three-way catalyst may be provided on a honeycomb shaped catalyst carrier. Zeolite may be used as an *HC* absorbent material.

If a stoichiometric air-fuel mixture is supplied to the engine 1, the exhaust gas is in a rich atmosphere due to the emitted *HC* from the *HC* absorbent catalytic converter 5 when the temperature of the exhaust gas reaches a temperature at which *HC* temporarily absorbed by the *HC* absorbent catalytic converter 5 is released. Herein, a rich atmosphere means an atmosphere in which the concentration of *HC* is high with respect to the amount of oxygen in the exhaust gases. On the other hand, a lean atmosphere means an atmosphere in which the amount of oxygen in the exhaust gases is in surplus.

However in the present embodiment, the *Rh* content by percentage in the *HC* absorbent catalytic converter 5 is greater than the *Rh* content by percentage in the three-way catalytic converter 4. *Rh* displays a high *HC* conversion ratio on comparison with other precious metal substrates even when the exhaust gas is in a rich atmosphere. As a result, even in a rich atmosphere resulting from *HC* emitted from the *HC* absorbent catalytic converter 5, *HC* is effectively oxygenated by the *HC* absorbent catalytic converter 5 and removed from the exhaust gases.

Thus as it is not necessary to control the air-fuel ratio greatly towards a lean air-fuel ratio when *HC* is being emitted in order to raise the oxygen concentration of

the exhaust gas flowing into the *HC* absorbent catalytic converter 5, NO_X emissions can be also reduced. Furthermore since *HC* removal by the *HC* absorbent catalytic converter 5 is improved, it is possible to dispense with the *Rh* component of the three-way catalytic converter 4.

Since the three-way catalytic converter 4 is provided in proximity to the high temperature exhaust manifold 2, the necessary time for the three-way catalytic converter 4 to reach an activation temperature is shortened which thus heightens the emission control characteristics of the three-way catalytic converter 4.

By using the *HC* absorbent catalytic converter with a coating of *HC* absorbent material on the surface of the honeycomb shaped catalyst carrier and a coating of a three-way catalyst on the coating of *HC* absorbent material, or by using the *HC* absorbent catalytic converter with a coating of a mixture of an *HC* absorbent material and a three-way catalyst on the honeycomb shaped catalyst carrier, *HC* released from the *HC* absorbent material may be quickly oxygenated and removed by the three-way catalyst which thus heightens the *HC* emission control characteristics.

If the total amount of the precious metal catalyst in the three-way catalytic converter 4 is made equal to the total amount of the precious metal catalyst in the *HC* absorbent catalytic converter 5, the same emission control characteristics may be obtained in the *HC* absorbent catalytic converter 5 as in the three-way catalytic converter 4.

Otherwise, if the total amount of the precious metal catalyst of the three-way catalytic converter 4 is made greater than the total amount of the precious metal catalyst of the *HC* absorbent catalytic converter 5, the redox reaction performed by the three-way catalytic converter 4 is increased and the heat of reaction is

consequently increased. As a result, it is possible to shorten the time for the three-way catalytic converter 4 to reach an activation temperature. Conversely, if the total amount of the precious metal catalyst of the *HC* absorbent catalytic converter 5 is made greater than total amount of the precious metal catalyst in the three-way catalytic converter 4, the redox reaction performed by the *HC* absorbent catalytic converter 5 is increased and the heat of reaction is also increased. Although the inflow gases into the *HC* absorbent catalytic converter 5 in a downstream position have a lower temperature than those inflowing into the three-way catalytic converter 4, it is possible to advance the time for the *HC* absorbent catalytic converter 5 to reach an activation temperature by employing the heat of reaction.

Figure 2 shows a second embodiment of the present invention.

The second embodiment differs from the first embodiment in that a second three-way catalytic converter 41 is provided downstream of the *HC* absorbent catalytic converter 5 and a second *HC* absorbent catalytic converter 51 is provided further downstream.

If the *Rh* content by percentage or amount of the three-way catalytic converter 4, the second three-way catalytic converter 41, the *HC* absorbent catalytic converter 5, and the second *HC* absorbent catalytic converter 51 are respectively taken to be *Crh4*, *Crh41*, *Crh5*, and *Crh51*, then

$$Crh51 > Crh5 > Crh41 \geq Crh4$$

If the *Pt* content by percentage or amount of the catalytic converter 4, 41, 5 and 51 is respectively taken to be *Cpt4*, *Cpt41*, *Cpt5*, and *Cpt51*, then

$$Cpt4 > Cpt5 \geq Cpt51 \geq Cpt41$$

A second embodiment of the present invention obtains the same effect as the first embodiment and furthermore achieves the advantage outlined below.

Since the three-way catalyst of the *HC* absorbent catalytic converter 5 has an oxygen storing function which is similar to that of the three-way catalytic converter 4, when *HC* absorbent catalytic converter 5, 51 are provided in series, oxygen is stored in the upstream *HC* absorbent catalytic converter 5 and the amount of oxygen supplied to the downstream *HC* absorbent catalytic converter 51 is reduced. However in the second embodiment, the *Rh* content by percentage or amount in the downstream *HC* absorbent catalytic converter 51 is greater than the *Rh* content by percentage or amount in the upstream *HC* absorbent catalytic converter 5. As a result, a high *HC* conversion ratio is also achieved in the downstream *HC* absorbent catalytic converter 51.

Furthermore, since the *HC* absorbent catalytic converter 5, 51 are provided in series, the time required for the respective catalytic converters 5, 51 to reach an activation temperature varies. As a result, it is possible to preserve a difference in the *HC* emission initiation times between the upstream *HC* absorbent catalytic converter 5, and the downstream *HC* absorbent catalytic converter 51. For example, it is possible to regulate the *HC* emission initiation times of the *HC* absorbent catalytic converters 5, 51 so that *HC* is absorbed by the *HC* absorbent catalytic converter 5 until the three-way catalytic converter 4 reaches an activation temperature and the second *HC* absorbent catalytic converter 51 absorbs *HC* until the second three-way catalytic converter 41 reaches an activation temperature.

The content by percentage or amount of *Pt* which enables a high conversion ratio even in atmospheres where the exhaust gas has a lean air-fuel ratio is higher in the upstream three-way catalytic converter 4 than in the downstream *HC* absorbent catalytic converters 5, 51. Therefore *HC* can be oxidized and removed even in atmospheres where the exhaust gas has a rich or a lean air-fuel ratio.

The entire contents of Japanese Patent Application P10-170239 (filed June 17, 1998) are incorporated herein by reference.

Although the invention has been described above by reference to certain embodiments of the invention, the invention is not limited to the embodiments described above. Modifications and variations of the embodiments described above will occur to those skilled in the art, in light of the above teachings.

The scope of the invention is defined with reference to the following claims.